BAT SURVEY OF THE HUALAPAI MOUNTAINS

Fiscal Years 1997-1998

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ABSTRACT

Bats were surveyed in the Hualapai Mountains primarily on BLM land between April 1997 and July, 1998, with at least one survey period in each season of the year. Survey methods included mist-netting; mine and diurnal roost surveys; and detection of bat sonar signals utilizing the Anabat II system and recording directly on a laptop computer. During this survey, 19 species of bats were detected acoustically in the vicinity of the Hualapai Mountains, including four species not previously documented from the range (spotted, western mastiff, Allen's lappet-eared and pocketed free-tailed bat). Day and/or night roosts were located for 10 species. Of the 15 species captured at least once in mist nets, there was evidence of reproduction for all but hoary and pocketed free-tailed bats. The California leaf-nosed bat roosted in several mines to the south of the Hualapai Mountains in Burro Creek Canyon. Four mines were identified as having importance for Townsend's big-eared bats, Cave myotis and/or long-legged myotis: the Warm Springs, Flag, Mary Nevada and San Francisco Mines, while the MacKenzie adit on the Boriana Road shelters five species, including a pallid bat maternity colony. Gating is recommended for some of the more accessible mines not currently receiving protection (MacKenzie and Warm Springs adit). Annual monitoring of the mines used by bats in the summer (and every other year for winter use) should be done to evaluate the success of the gates or determine if gates are needed. To monitor long-term trends of bat populations, mist netting with consistent protocols should be conducted annually at low and high elevation site in the Hualapai Mountains, concurrent with the recording of echolocation signals on the Anabat II system. Water sources (such as livestock tanks) should be monitored for bat use, and evaluated as to their importance for bats in management recommendations.

INTRODUCTION

The purpose of the current survey funded by the an Arizona Game and Fish Heritage grant to the BLM Kingman Field Office was to provide baseline data on the status of bats and critical roost sites in the Hualapai Mountains, Mohave County, Arizona. Specific objectives of this project were:

A. To identify the bat species using the Hualapai Mountains, particularly those species formerly listed as Threatened Native Wildlife by the Arizona Game and Fish Department (aka Wildlife of Special Concern);

B. To identify seasonal bat roost sites in the Hualapai Mountains; and

C. To provide management recommendations to Federal and State agencies to protect bat species and their critical habitat in the Hualapai Mountains.

Bat populations have declined throughout the southwest. Human-related factors, including habitat destruction, roost vandalism, poisoning by pesticides, renewed mining, and collection for scientific and public health purposes, have contributed to this decline. To stabilize and reverse this alarming trend, remaining bat roosts must be identified and aggressively protected through cooperative management.

The Arizona Game and Fish Department has determined that bat conservation is a priority; however, the task statewide is extensive.

The Hualapai Mountains are the western-most "sky island" mountain range in Arizona. The elevational range (ca 3,300 - 8,400 feet) and associated vegetative communities (Mohave desert scrub, desert grassland, chaparral, juniper-pinyin woodland, montane conifer forest) of the Hualapais, correspondingly increases potential for seasonal and resident faunal diversity in this unique geographic area. However, the beauty of this mountain range (and its proximity to major highways and urban areas) is attracting human development and recreation, especially in the northern part. Increased recreational mine exploration has the potential to disturb roosting bats. Many mines have already been closed in the mountains in response to human safety issues.

Although this project emphasized locating critical roosts of sensitive bat species (either state-listed or formally listed as Federal Category II species) such as the California leaf-nosed bat (*Macrotus californicus*), western mastiff bat (*Eumops perotis*), Townsend's big-eared bat (*Plecotus=Corynorhinus townsendii*), Allen's lappet-eared bat (*Idionycteris phyllotis*), and spotted bat (*Euderma maculatum)*, the presence of more common bat species was also documented. Information gathered on occurrence and distribution, population trends, and habitat requirements of bats in the Hualapai Mountains during this study can be used in developing management policies and strategies for the protection and recovery of these sensitive species.

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METHODS

Field work under this AGFD Heritage Fund was conducted over 39 days in each season: from April 28-May 5, 1997; July 22-23, 1997; August 18-19, 1997; October 13-21, 1997; January 6-12, 1998 and July 1-11, 1998. Field personnel included Dr. Patricia Brown and Dr. Robert Berry, with the following people assisting at some time during the survey: Jim Witham, Angie McIntyre, Mark Brennan, and Richard Winstead (Arizona Game and Fish Department); Jim Rorabaugh (U.S.Fish and Wildlife Service); Bob Hall, Julie Landreth, Gary Sexton, Rebecca Peck, and Dave Smith (Bureau of Land Management); Karen Miner (California Department of Parks and Recreation); Scott Altenbach (University of New Mexico); unaffiliated volunteers Cynthia Vann and Chuck Pease; and Shawn Castner (formerly AGFD).

Field techniques included entering mines at different seasons to search for bats or guano, counting bats flying out of mines with the aid of night vision equipment, mist netting outside of mines and over water sources, searching under cliffs and

rock crevices for evidence of bat use, and monitoring sonar signals at night with ultrasonic detection equipment. Prior to the survey in March 1997, a reconnaissance flight in a single engine Cessna provided preliminary information on mine and water locations. In July 1998, (after gaining familiarity with the mountains from the ground), another flight was made to determine what mines still needed to be surveyed.

Mines provide ideal day and night roosts for several species of bats (Tuttle and Taylor, 1994). If the mine could be safely entered and totally accessed, the bats and guano were identified. Within the mine, bats often were captured in hand nets for identification and information on age, sex and reproductive condition. Bats were not disturbed in a maternity colony or during hibernation. Most bat guano was identified as to genus by size, shape, odor and deposition pattern, even when the bats were not present. The amount of guano can be related to population size. Temperatures were taken in the accessible areas of the mines that the bats used for roosting. If guano and/or insect remains were found during the day, but no bats were present, then the mine was revisited at night or in another season to identify bat use. In the case of vertical shafts or horizontal adits that contained inaccessible areas (raises, winzes, stoped areas or deep crevices), then the presence of bats was detected by watching the portals for at least an hour after dusk for bat emergence during the warmer months. Generation 3 Varo night vision equipment with auxiliary red or infrared light sources was used to monitor bat activity. To count the outflights, finger tallies were employed with the net number of bats determined by subtracting the number of bats entering from those leaving the mine. If identification could not be made on the basis of size and flight pattern of the bat, then mist-netting at mine entrances was sometimes employed, with the net being set after the outflight count was finished. Mist-netting also verified which resident bat species were leaving the mine at dusk, and which were entering to night roost by setting the net before dusk over the mine portal. Mine roosts and mist-netting sites were usually photographed with film and/or digital cameras, and locations recorded from 7 1/2 minute topographic maps and/or a Global Positioning System receiver (Magellan 2000).

Mist nets of various sizes were spread for at least 4 nights at each season (excluding winter) in various spots, usually over water tanks, washes or mine portals. At least two to three nets were set each night for at least two hours after dusk and continuously checked. For one night each season, the nets were tended from dusk until dawn, in an effort to capture late-flying bats, such as the spotted bat (*Euderma maculatum*). All bats captured were immediately removed, identified as to species, sex, age and reproductive condition. Weather conditions were also recorded.

Sonar signals of bats were monitored using several varieties of bat detectors: Anabat 2, Ultrasound Advice mini-detector, and Pettersson D-100, D 230, and D-980 detectors. The Anabat 2 detector with a delay switch and tape recorder was used to remotely record bat signals with a time stamp. Monitoring the level of bat activity (bat passes/unit time) with bat detectors can give a relative index of bat activity for different seasons and areas. This data can be used to determine bat foraging habitat for future mist-netting sites. An Anabat II detector (Titley Electronics of Australia) with a zero crossing analysis interface module and Anabat 5 software was used to view and store echolocation signals on a laptop computer. Field recordings were taken nearly every night while mist netting for bats. The recordings consisted of binary data files stored on the laptop

computer's hard drive. Each time a bat was caught in a mist net and identified, a data recording of its echolocation calls was made as the bat was released. These files were carefully marked to establish a library of calls from each of the species captured in the Hualapai Mountains. Recordings taken at other geographic locations augmented the library of calls. Some species could be reliably identified by vocalizations, especially when combined with visual cues (size and flight behavior). Some vespertilionids utilize signals that may overlap in frequency depending on the bats perceptual task. *Macrotus* and *Corynorhinus* use signals that are too low in intensity to be recorded unless the bat is at close range. Some species of bats (*Euderma, Idionycteris, Eumops* and *Nyctinomops*) emit lower frequency signals audible to (younger) human ears without a detector. Other species, such as *Antrozous* and *Macrotus*, use human-audible communication sounds.

The original proposal indicated that transmitters would be placed on larger-bodied bats of special management concern (*Eumops, Euderma, Idionycteris* and *Corynorhinus*) that were captured in mist nets in order to determine roost locations and foraging areas. None of the other target species were captured in mist nets during the study. *Corynorhinus* was encountered at roosts during the study, so the need to locate roosts through telemetry was not necessary. Any funds budgeted for telemetry in the original proposal were used for mine, acoustic and mist-netting surveys.

RESULTS

A total of 19 species of bats were detected in or near the Hualapai Mountains between May 1997 and July 1998 (Table 1). Two of these species were found southeast of the Hualapai Mountains. *Macrotus* was discovered roosting in the Burro Creek Mines in October and detected acoustically at the Big Sandy Bridge in July, while *Nyctinomops macrotis* was recorded over the trailer park in Wickieup in October. Of the 15 species mist-netted or captured in hand nets in the Hualapai Mountains, all but two showed evidence of reproduction (pregnant, lactating or post-lactating females or juveniles). Only male hoary bats (*Lasiurus cinereus*) were captured at all seasons except winter. The presence of four species was determined acoustically (*Eumops perotis, Idionycteris phyllotis, Euderma maculatum and Nyctinomops macrotis*), so no information on their reproductive status was available. The locations and dates of data collection are listed in Table 2.

Roost Surveys:

Of the 19 species of bats detected during this survey, at least one roost locality was found for over half (10 species). For two species, the only evidence was the presence of guano: *Nyctinomops femorrosaccus* guano under a crevice near Warm Springs and *Tadarida* guano in a natural cave in the same area. Except for the these natural roost sites, and the bats night roosting under the Big Sandy Bridge and at the Castle ruins, all of the other roosts located were in abandoned mines.

During the course of the survey, 30 of the 32 mine features surveyed for bats contained bats or guano (Table 3), indicating bat use at some time of day or season of the year. All workings could be partially entered to look for bats and/or guano. Most of the guano was left by *Corynorhinus*, mid-sized *Myotis sp., Eptesicus* and *Antrozous*. The mines around Burro Creek contained *Macrotus* guano. *Corynorhinus* or *Myotis velifer, thysanodes, volans or ciliolabrum* were encountered during diurnal surveys, while *Eptesicus* and *Antrozous* were usually only found in mines at night. They may have been concealed in crevices during diurnal surveys, or entered the mines after dark for night roosting. This behavior is also observed for some of the *Myotis* species.

Since many of the workings had multiple openings and possible connecting drifts, raises and winzes, an accurate assessment of bat use was at times difficult. Exit counts using night vision equipment were conducted on 5 mines that were expected to contain large numbers of bats (Flag, Mary Nevada, San Francisco, MacKenzie and Telegraph adit). Some of these mines had multiple entrances to a single mine complex, and required at least 3 observers for an outflight count (i.e. Flag and Mary Nevada). These mines were watched because they could not be safely entered or had areas within the mine that were impossible to survey. Except for the Telegraph adit, these mines were surveyed at different times of the year to observe changes in the number of bats or the species composition. The Flag Mine (with extensive historic data of bat use) was monitored five times so bat use at all seasons could be compared. The more significant mine roosts are described below.

Flag Mine

The Flag Mine is located in Ponderosa pine forest on the main road down the spine of the Hualapai Mountains. The lower adit on the road level is secured with a bat gate installed in 1993 to alleviate heavy human recreational use, another adit portal about 100 feet above is collapsed, and two open shafts are located above this. The lower adit contains standing water at all seasons, and can be accessed for about 150 meters before dangerous collapses prevent further surveys. At this point, a raise leads up to higher levels, This complex mine is difficult to survey for bats because of the large areas that cannot be accessed. From Musgrove's records (Cockrum et al., 1996), the Flag Mine was a major hibernation site for bats in the early 1960's, especially *Eptesicus* and *Corynorhinus* (1500+ in January 1962). The number of bats now using the mine appeared to have declined by an order of magnitude (about 102 torpid *Corynorhinus* and one *Myotis ciliolabrum* in January 1998).

Because of the water in the mine, non-resident bats will enter the lower adit after dark to drink, so two-way bat traffic exists at all hours from spring through fall. Musgrove's data do not differentiate between exiting or entering bats netted near the mine, but the following species were present: *Myotis thysanodes, volans, ciliolabrum,* and *californicus; Eptesicus; Antrozous; Pipistrellus*; and *Corynorhinus*. Males and females were captured for all species (except for only male *M. californicus*). In contrast during the spring and summer, we captured male and reproductive female *Myotis volans,* but only male *Corynorhinus, Myotis thysanodes* and *ciliolabrum.* Acoustic recordings made outside the mine were attributable to all the species captured by Musgrove (Cockrum et al., 1996), with the exception of *Antrozous* and the addition of *Myotis occultus* and *Tadarida* (probably flying high overhead). Based on the 1998 summer captures, a small maternity colony of *Myotis volans* appears to roost in the Flag Mine, as well as male *Corynorhinus, Myotis thysanodes, ciliolabrum* and *volans*. About 40 *Myotis*

sp. and 20 *Corynorhinus* exited the mine in July. During the October survey, the mine appeared to be used by *Corynorhinus* as a breeding area, with at least 140 bats counted leaving the shaft and adit after dark. Reproductive (testes descended) males and females were captured at the portal. The *Corynorhinus* guano found several hundred feet within the mine under the open stope was probably deposited in the fall.

Mary Nevada Mine

This complex mine is located on the north side of Diamond Joe Peak, and is not accessible to vehicles. The lowest level contains over 500 meters of drifts, plus raises to upper levels, finally terminating at a shaft on the ridge 300 feet above, creating strong air currents in the mine. Another shaft on the drainage to the west collects water during rains, and causes seasonal flooding in the lowest level. During the winter, 74 torpid *Corynorhinus* were observed in the mine as well as two each of *Myotis velifer* and *ciliolabrum.* July outflight counts revealed at least a dozen *Corynorhinus* and 50 *Myotis* sp. leaving the mine from the adit and lower shaft (no bats used the upper shaft). Two way traffic made the census difficult. Lactating *Myotis volans* and male *Corynorhinus, Myotis thysanodes, ciliolabrum, velifer* and *volans* were captured in a mist net at the mine portal after the outflight. The conclusions are that the mine is an important hibernation site for *Corynorhinus* as well as sheltering a small maternity colony of *Myotis volans* (and males of 5 species). In addition to the signals of the 5 species captured at the mine, echolocation calls of *Antrozous, Myotis californicus, Pipistrellus* and *Tadarida* were recorded in the vicinity.

MacKenzie Adit

This adit is located within view of the Boriana Mine road and appears to receive a fair amount of human visitation. The main adit ends at a shaft that comes in from above and continues below, with drifts extending right and left. The left drift cannot be easily accessed, and this is probably where most of the bats roost. Guano of several species (*Corynorhinus, Antrozous, Eptesicus* and *Myotis*) attest to bat use of the mine. When the mine was entered during the day in May, only one *Corynorhinus* was observed in the accessible area of the mine. In July, at least 25 *Antrozous* exited from the mine after dark, and when the mine was entered 90 minutes later, lactating *Antrozous, Eptesicus* and *Myotis volans*, and a male *Myotis thysanodes* were night-roosting in the mine. Outside of the mine, echolocation signals of *Pipistrellus, Eptesicus, Antrozous, Myotis californicus* and *ciliolabrum* were recorded. In January, 5 active *Corynorhinus* were observed flying in the mine after dark.

San Francisco Mine

This complex mine is wet for most of its length, with many winzes below the main level filled with water. Several stopes lead to an upper shaft entrance. The majority of the bat activity is at the lower adit. In July, it shelters a maternity colony of over 100 *Myotis velifer*, and a few *Corynorhinus* (one male captured). In addition to these two species, echolocation signals of *Myotis californicus* were recorded near the mine. In the fall, the mine appears to be used as a breeding site for *Corynorhinus*, with about 50 bats exiting at disk, but continuous two-way traffic. When the mine was entered 2 hours after dark, at least 20 active bats were observed. In addition, male *Myotis velifer* and *volans* were captured in a mist net at the portal.

Telegraph Adit, Burro Creek Canyon

Although this mine is located south of the Hualapai Mountains, it was visited during the current survey. In October, over 800 *Macrotus* exited from the mine at dusk. When the mine was entered in the afternoon, males and females were captured in hand nets, and the pre-copulatory wing-flapping display of the males was observed. *Macrotus* form large aggregations in specific mines in the fall for courtship and mating. The large amount of guano and high ammonia concentration in the mine was indicative of a large maternity colony of *Myotis velifer* using the mine in the summer. On the east side of the hill from the Telegraph adit, **Burro Mines #**1-4 contained large amounts of *Macrotus* guano, and could possibly be used by that species during the maternity season. A few male *Corynorhinus* were captured in these adits.

Warm Springs Adit

This adit is located a mile to the north of Burro Creek Canyon in Kaiser Canyon and is probably used by a maternity colony of *Corynorhinus* (post-lactating females and juveniles were captured there), but *Macrotus* guano is also present. The adit appears to receive regular human visitation, and gating is recommended.

Mist-netting

During over 200 net/hours, 381 bats of 15 species were captured (Table 3), the majority in the first two hours of the night. Reproductive females or juveniles were captured for all species, with the exception of *Lasiurus cinereus* and *Nyctinomops femorrosaccus* (which escaped from the net before any determination could be made). For the spring and fall 1997 season, nets were tended all night over the Twin Windmills tanks, where 8 bat species were taken. This was a site regularly sampled by Musgrove (Cockrum et al., 1996) between 1959-62 on at least 27 occasions, during which time 9 species were captured (the same as for this survey plus 2 *Tadarida*). Due to vandalism of the tanks, Twin Windmills was not available for netting in summer 1998, and the all night netting session was conducted at the tank near the Frost Mine, where 7 species were captured. In addition to mist-netting over water at tanks, ponds and streams, nets were set across the entrances of the Flag, Mary Nevada, San Francisco, Odle, Warm Springs, and Frost mines to monitor sex and/or reproductive condition of the bats.

Sonar Signals

Bats were recorded via the Anabat on a laptop computer for over 90 hours during the warm season surveys at mist netting sites and near roosts. Later analysis of the recordings as to species present was possible for most bats (Table 4). Signals attributable to all 19 species were recorded at least once during the survey. While mist-netting verified the presence of 15 of those species recorded, the occurrence of four species (*Eumops perotis, Idionycteris phyllotis, Euderma maculatum and Nyctinomops macrotis*) was determined solely from echolocation signals. With the exception of *N. macrotis*, none of these species have been previously captured in the Hualapai Mountains. Only one train of signals for *Idionycteris* was recorded over Pine Lake in July. All of these species emit

human audible calls, and listeners with good high frequency hearing also verified the presence of *Eumops, Euderma* and *Nyctinomops* sp. (*macrotis* and *femorrosaccus* are difficult to distinguish) at several locations. These "hearings" are noted as audible in Table 4, as well as those that were only determined from calls recorded on the computer. The data is also on a computer disk included with this report (aka voucher signals). Some species of bats, such as *Macrotus* and *Corynorhinus*, emit very faint signals, and are termed "whispering bats". Their signals are usually detectable at very close range (less than 10 feet) and so they are under-represented in the acoustic data, whereas the free-tailed bats emit loud signals that may be projected hundreds of feet.

The identification of bats based on recordings using the Anabat detector and software is gaining acceptance in the scientific community (O'Farrell and Gannon, 1999; O'Farrell et al., 1999). Some species overlap in many parameters of their echolocation signals (frequency, rate of sweep, duration, repetition rate, etc.). A single bat species can emit varying echolocation pulses that enable the bat to most effectively extract data. Parameters are changed based on the bat's activity, the environment and the information requirements. The goal of recent field research has been to determine if any portion of the echolocation signals can be used to reliably identify species. A train of pulses, preferably search phase (when the bat is looking for and not in final pursuit of prey), is necessary to make a good identification. When bats are captured in mist nets, and signals are recorded on release, they may not always be representative of the species' signals when hunting. Good calls are seldom made immediately following hand release because the bat is anxious to acquire as much information about his surroundings as possible in the least amount of time. These "hand release" calls may look the same over a wide range of species. If the release is made in an open field away from conflicting echolocation calls, and the released bat can be visually followed as it's recorded for over 10 seconds, then good definitive recordings may be acquired. Also, recording outside a roost of a known species during exodus will often result in "library quality" calls.

The 868 data files collected during the survey were examined in an attempt to correlate with a particular bat species. Each calling sequence was compared with calls from the "library" to find the closest match. In some cases there was no match, and that file would be labeled as non-identifiable. Some species give calls that overlap with other species and confuse the absolute identity of the bat. At some locations a bat species was identified by its acoustic recording, but was not caught in a mist net. The signals were then carefully checked against the library of calls. If the call could be confused with other species, then an additional judgment was made as to the 'most likely' of those species to be present at that location. For example, *Tadarida* has a very large repertoire of sounds, and a definitive search phase of an almost flat 22kHz call of 15 msec. duration repeated 2-3 times a second. When flying in clutter or closing with prey the call sweeps through a wider (and higher) frequency range, shortens and is repeated 5 -10 times per second. *Eptesicus* make similar calls to these and can easily be confused. *Eptesicus* and *Antrozous* have calls that overlap; as do *Euderma* and *Idionycteris*. However, each of these species does emit definitive signals. *Antrozous* will often emit an audible "directive" following its echolocation call. *Idionycteris* will sometimes make a very unique call that is a warbling 25khz for 35milliseconds with a sharp drop off (~200 octaves/second) in frequency to

8khz. One such call was recorded at the inlet creek to Pine Lake on the night of July 11, 1998 providing an extremely high probability that these bats are present in the Hualapai Mountains.

DISCUSSION

The Hualapai Mountains supports a rich and varied bat fauna that has been the focus of several previous studies. Between July 1959 and March 1964, Bill Musgrove and his students surveyed and banded bats in Mojave County. This information has been compiled into a manuscript with detailed locations (Cockrum, Musgrove and Petryszyn, 1996). This paper also includes data from Hoffmeister (1986). Since some of the collection sites in the Hualapai Mountains can still be located, it provides the opportunity to look at changes in bat distribution over the past 35-40 years. In 1993, AGFD biologists Tim Snow and Shawn Castner conducted bat surveys in some areas of the Hualapais (Castner, Snow and Noel, 1994), and their field notes were available for this survey. Bob Hall (Kingman BLM) and others have been monitoring bat populations in the Flag Mine since 1992.

Many of the species detected during the present survey have been previously collected in the Hualapais or could be deduced from current range maps (Barbour and Davis, 1969; Hoffmeister, 1986)), with the exception of *Idionycteris, Eumops, Euderma*, and *Nyctinomops femorrosaccus.* The first three of these species were documented as occurring in the Hualapai Mountains in this study based only on acoustic records. All of the other species were captured in mist nets either in the vicinity of the Hualapai Mountains either in this survey or previous ones. *Myotis occultus* and *velifer* were not recorded in the Hualapais until the 1993 study of Castner and Snow. A suite of survey techniques is necessary to document the occurrence of different species. Mist netting is best for species that regularly come to water sources to drink (*Myotis sp., Pipistrellus, Eptesicus, Lasiurus*); mine surveys are the best technique to locate the "whispering bats" (*Macrotus* and *Corynorhinus*); while acoustic records may be the only way to document the high-flying molossids and *Euderma*.

Seven species of ***Myotis*** have been found in the Hualapai Mountains. ***Myotis ciliolabrum*** and ***californicus*** are closely-related and sometimes difficult to distinguish from one another in hand, but often can be separated via acoustic records. The *M. ciliolabrum* typically occurs at higher elevations and more wooded habitats, and *M. californicus* is a common bat at low elevations in the desert. In the Hualapais, *M. ciliolabrum* was absent from the lowest elevation sites (Burro Creek, Big Sandy bridge) but present above 2,500 feet, whereas M. californicus was netted or detected acoustically from the lowest (Burro Creek) to the highest (Boy Scout Pond) survey locations. A few *Myotis ciliolabrum* were discovered hibernating in the Flag and Mary Nevada Mines, and night-roosting at the Boriana, Flag and Mary Nevada Mines. No roosts for *Myotis californicus* were found, and all records are from mist-netting or acoustic records.

Myotis occultus was not recorded from the Hualapais by Musgrove (Cockrum et al., 1996), but he collected two individuals from mines in the Burro Creek area. Hoffmeister (1986) shows the westernmost extension of the bats to be several hundred miles east of the Hualapai Mountains (although the type specimen was from along the Colorado River). In July 1983, Castner and Snow mist-netted a *M. occultus* at the entrance to the Flag Mine. In this survey, a juvenile male was mist-netted in July over Pine Lake. Echolocation signals attributable to *M.*

occultus were recorded at the Flag Mine, Pine Lake, Moss Wash and Boy Scout Pond.

The closest locations to the Hualapai Mountains given for ***Myotis velifer*** by Musgrove (Cockrum et al., 1996) are in the mine along Burro Creek (Telegraph adit). This maternity roost was verified by Castner and Snow, who also found a male of this species roosting in the Enterprise Mine in the Hualapais. When the Telegraph adit was visited in October 1997, the bats had already left the mine for the season, although their echolocation signals were recorded in the vicinity. In July 1998, pregnant and lactating *M. velifer* were mist-netted under the Big Sandy Bridge of Highway 93, and several hundred bats night-roosted under the bridge. A significant maternity colony of *Myotis velifer* was discovered at the San Francisco Mine. Only a few males were captured during the summer in the Mary Nevada Mine, and two hibernating bats were observed here in the winter. In the summer, cave myotis were also mist-netted at Stout's Well and Delgado Spring.

Myotis yumanensis is usually found near sizable bodies of water. Musgrove (Cockrum et al., 1996) captured a few individuals near Burro Creek, although the largest colonies for this species are along the Colorado River. Castner and Snow captured a *M. yumanensis* at the entrance to the Flag Mine in August, 1993. During this survey, a lactating female was captured south of the Hualapais at the Big Sandy bridge, and echolocation signals were recorded here and at Burro Creek. An adult male was captured at Pine Lake in July, and echolocation signals were recorded here and at Odle Ranch Pond. These two ponds have the largest water area in the Hualapais, and the Yuma myotis were observed skimming over the water surface.

Myotis volans are usually found above 3500 feet elevation in the Hualapai Mountains. The lowest elevation capture was a lactating female night-roosting in the MacKenzie Mine. Reproductive females and juveniles were mist-netted exiting and entering the Flag and Mary Nevada Mines, probably indicative of small maternity colonies. Males were captured in the same locations as well as the Boriana, Frost and San Francisco Mines. Both sexes were captured in mist nets at the Twin Windmills and Frost Tank. No hibernating *M. volans* were found during this survey, but Musgrove (Cockrum et al., 1996) reported capturing two males in the Flag mine in January 1962.

Myotis thysanodes is another species found at higher elevations in the Hualapai Mountains, with a male in the MacKenzie Mine representing the lowest elevation capture in this survey. No maternity colony sites were found for this species during the survey, although reproductive females and/or juveniles were netted at upper Moss Wash tank, Delgado Spring, the Castle ruins, Twin Windmills, Frost Tank and "Rocky's tank". Males were captured at most of these locations as well as at the Mary Nevada and Flag Mines and Boy Scout Pond (higher elevation sites than those used by females). The Flag Mine shelters a colony of about 40 males as judged by outflight counts, and the capture as they exited the mine. No hibernating *M. thysanodes* were found during this survey, but in January 1962, two torpid males were found in the Flag Mine (Cockrum et. al., 1996).

Pipistrellus hesperus were recorded and/or captured in mist nets at several places in the Hualapais from the around 1000 feet at Burro Creek to Boy Scout pond at almost 8,000 feet. No roosting sites were located, as was also the case in Musgrove's study (Cockrum et al., 1996). Reproductive females, juveniles

and/or males were captured in mist nets at Boriana Mine Tank, Twin Windmills, Stout's Well, Frost Tank, Big Sandy Bridge and Pine Lake.

Eptesicus fuscus were usually found at elevations above 3500 feet in the Hualapais where they were one of the more common species captured over water tanks, including Twin Windmills, Boriana Mine tank, Boriana Spring, Frost Tank, Rocky's tank, Moss Ridge Pond, Pine Lake and Boy Scout Pond (where 32 were captured in one night). The higher numbers of females at Rocky's tank and Frost tank are probably indicative of maternity colonies in the vicinity. No day roosts were found during this survey, although in 1962-63 they roosted in the Flag Mine in the winter and summer (Cockrum et al., 1996). A male *Eptesicus* was found in the Kabba Mine at night in May 1997 and a lactating female was captured in the Mackenzie Mine after dark.

Five male ***Lasiurus cinereus*** were mist netted in the spring and summer at Boriana Spring, Moss Ridge pond, Pine Lake and Boy Scout Pond. In addition echolocation signals attributable to them were recorded at these and other locations near Moss Wash and Twin Windmills. Musgrove (Cockrum et al., 1996) only netted one male hoary bat during his surveys. The females of this species are presumed to migrate further north in the summer, while some males remain in the Hualapai Mountains. In the fall, both sexes migrate south and presumably overwinter in Mexico.

Antrozous pallidus were usually encountered at low to mid-elevations in the Hualapais. A maternity colony of about 25 bats uses the MacKenzie Mine, and reproductive females have been mist-netted at Twin Windmills, Moss Wash Tank, Warm Springs, Big Sandy Bridge, and Frost Tank. The characteristic communication signals of pallid bats are usually emitted frequently near roosts, and a maternity roost probably is close to Moss Wash Tank and Frost Tank. Day roosts can be in rock crevice and hollow trees, as well as mines. This species often use mines as night roosts, and distinctive guano piles and insect remains were found in the Goat adit, MacKenzie Mine, Kabba Mine, Tompkin's Canyon Mine, the Castle, Odle Mine, and Chappo Spring Mine. Echolocation signals of *Antrozous* were recorded at Boy Scout Pond, Pine Lake, Mary Nevada, Boriana, Kabba and Flag Mines, although no bats were captured in mist nets at these locations.

Corynorhinus townsendii was the species found in the most number of mines, although usually a working might contain only a single male or two. This was the case for the Frost Mine, Goat adit, Boriana Mine, Standard Mineral Mine, Burro Mines, Golden King Mine, Moon Mine, Mica Giant Mine and Iguana Mine. The distinctive guano of this species was found in several other mines. No maternity colonies were located in the Hualapais, although the Warm Springs adit to the south appears to shelter one. Reproductive females and/or juveniles were captured in mist nets there as well as Twin Windmills and Boy Scout Pond. The San Francisco Mine is a swarming site in October with reproductive males and females continuously entering and exiting the mine. The Flag Mine is used in the same way in the fall, some males roost in the mine in the summer, but in winter it is a major hibernation site. In January over 100 *Corynorhinus* were counted in the accessible portions of the mine. This seems like a lot of bats now, but in December 1961 Musgrove (Cockrum et al., 1996) found over 1000, and in January 1962 over 1500 were hibernating in the mine. Several hundred bats were banded at each time, and in January 1963, Musgrove reported that only 100 bats were present. It is probable that the disturbance caused by entry into the mine during hibernation, and banding might have caused their decline (and

the disappearance also of the *Eptesicus*). Possibly the bats have moved to less human-accessible areas of the mine, although the coldest temperatures of 49 F (best for hibernation) should be in the lowest level. The present gate was installed in 1993, and hopefully the colony size is increasing. The Mary Nevada Mine does not provide temperatures as cold as the Flag, but about 75 hibernating *Corynorhinus* were in the mine in January. A small colony of about a dozen males roosts in this mine in the summer.

Corynorhinus is considered to be declining in numbers throughout its range (Idaho State Conservation Effort, 1995; Western Bat Working Group, 1998). Although several contributing causes are cited, the greatest threat is from roost disturbance. This cave and mine roosting species is very sensitive to human entry, especially during maternity and hibernation seasons. Temperature appears to be the key factor in roost selection, with cooler areas necessary for winter torpor and warm temperatures desirable for maternity colonies.

Idionycteris phyllotis has not been captured in the Hualapai Mountains. Three mines in the Black Mountains to the northwest shelter maternity colonies. To the north and east in Arizona, this species has been reported roosting in trees (Rabe et al., 1998). Their occurrence in the Hualapais would be predicted. The echolocation signal of *Idionycteris* has been reported to overlap in quality with *Euderma* (Corben, 1999, pers.comm), so potentially some of the signals attributed to *Euderma* may be *Idionycteris*. *Idionycteris* does emit a very long low, low frequency "warble" that is quite distinctive. One of these signals was recorded by Pine Lake in July 1998.

Euderma maculatum has not been previously recorded from the Hualapai Mountains. It has been taken further north in the vicinity of the North Rim of the Grand Canyon and at Ft. Pierce Wash. This bat emits a characteristic audible sonar call that was heard in several locations during this study, and always near water. As previously noted, some of the signals may have been *Idionycteris*. However, a spotted bat was definitely spotlighted at Pine Lake as it flew over a mist net in July 1998. Locations where *Euderma* was detected by ear and/or computer included Pine Lake, Boy Scout Pond, Odle Ranch Pond and Big Sandy Bridge, all in July 1998.

Eumops perotis also emits a distinctive human-audible echolocation signal. Prior to this survey, this species was not recorded from the Hualapai Mountains, although Musgrove (Cockrum et al., 1996) found a male in a crevice at Burro Creek in October 1962. *Eumops* is very rarely captured in mist nets, although recently they have been captured by AGFD biologists in northern Arizona, so their presence in the Hualapais is not surprising. A previous survey along the Bill Williams River documented their presence there. The cliff faces preferred as roosting habitat are found throughout the Hualapai Mountains. Single passes of *Eumops* were recorded at Big Sandy Bridge, the Mary Nevada Mine, and Frost Tank, while multiple signals were heard over the Odle Ranch Pond and Boy Scout Pond, all in July 1998.

Cliff faces are also preferred roosting habitat for ***Nyctinomops macrotis*** and ***femorrosaccus.*** The former species was mist-netted over a tank in the northern Hualapai mountains by Musgrove (Cockrum et al., 1996) in August 1961. Although no specimens were netted during this survey, the distinctive echolocation signals were recorded at Warm Springs and over Wickieup in October 1997. *Nyctinomops femorrosaccus* was recorded on several occasions in different locations, and one was captured in a mist net over Stout's Well in July

1997. Guano attributable to the species was found in a crevice near Warm Springs. Echolocation signals were recorded there as well as Moss Wash, Burro Creek, Twin Windmills, Big Sandy Bridge, Frost Tank, Odle Ranch Pond, Pine Lake and Boy Scout Pond. Pocketed free-tailed bats were netted over the Bill Williams River near Planet Ranch in 1994-95.

Tadarida brasiliensis were recorded at most locations in the Hualapai Mountains during this study. They were captured in mist nets at the Boriana Mine tank (15 males, I female), Stout's Well, Delgado Spring, Rocky's Tank and Boy Scout Pond. The only reproductive females were taken in mist nets by the Big Sandy Bridge. Possibly only males and non-reproductive females are in the Hualapai Mountains in the summer, with the maternity colonies located at lower elevations.

Macrotus californicus belongs to the Neotropical family Phyllostomidae. As with other members of the family, this species is unable to lower its body temperature and enter torpor, as do other temperate zone bats. Consequentially, *Macrotus* selects warm mines and caves as roosts usually with year-round temperatures above 80 F. Their distribution throughout the Sonoran and Colorado Deserts is determined by the availability of warm roosts near the desert washes, where they forage by gleaning large insects from the vegetation. Radio-telemetry studies in California have shown that, in the winter, bats usually forage in desert riparian vegetation within a mile of their roosts, but in warmer months, they may travel up to 5 miles.

Macrotus was not captured or detected in the Hualapai Mountains proper. Most roosts for this species are located below 2500 feet elevation. No warm mines were located in the Hualapais. The area around Burro Canyon and Warm Springs appears to support a large population. In October 1997, about 800 bats emerged from the "Telegraph" adit, although bats were constantly exiting and entering the mine. The wing-flapping and vocalizations of males in the mines was indicative that this was a courtship or lek area for this species. The guano deposition of some of the Burro Mines and the Warm Springs adit suggests that they may be used during the maternity season.

MANAGEMENT RECOMMENDATIONS

Roosting colonial bats require special protection, especially when they occur in mines accessible to the general public. The Hualapai Mountains are receiving increased recreational visitation. For public safety and the protection of the bats, several mines should be gated.

1. Install bat gate on the **MacKenzie Mine**. This mine is close to the Boriana Road. The bats do not appear to use the accessible portion of the adit for day roosting, probably because of human visitation. Five species of bats have been captured in the mine (including *Corynorhinus* in the winter), and it shelters an *Antrozous* maternity colony. After gate installation, the mine should be monitored on an annual basis during the warm season with night vision equipment (both the adit and shaft above it), and echolocation signals recorded. The mine should be surveyed every two years for over-wintering bats.

2. Install a gate on the **San Francisco Mine** (if land exchange can be arranged). This mine is an important *Myotis velifer* roost and a breeding site for *Corynorhinus*.

3. Monitor the **Mary Nevada** for human entry by spreading fire clay near the portal (or some other material that would record footprints). Checking for footprints could be done at the end of winter and summer. If people are entering the mine, then a gate should be considered. This mine is an important hibernation site for *Corynorhinus* and shelters five species during the warmer months, including a small maternity colony of *Myotis volans.*

4. Install a bat gate on the **Warm Springs** adit. This accessible mine is a maternity roost for *Corynorhinus* and also shelters *Macrotus.*

5. If mines are gated, their success should be monitored over time by counting bats exiting at different seasons. This includes the **Flag Mine** that has had a gate for some years. Exit counts should also be conducted at non-gated bat roosts in the vicinity at the same time with standardized protocol. Observers with night vision equipment and infrared lights should quietly position themselves at sunset on a calm night at all of the openings to a mine, and count for a consistent period after the first bat emerges (usually an hour), or until more bats begin to enter than exit the mine (this works at all seasons unless the mine is used as a fall swarming site). Counts should be made with finger tallies or tape-recorded voice notes. To compare data between years, the date (plus or minus a week) and moonphase and other environmental parameters of the survey nights should be equivalent. Sonar signals could also be recorded with an Anabat system. Hibernation sites should not be entered more than every other year, and then a census done quickly and quietly to minimize disturbance to the bats.

6. At least one lower elevation water tank (**Twin Windmills**) and one higher elevation site (**Boy Scout Pond**) should be netted on a calm night on an annual basis at the same season to monitor long-term population fluctuations of bat species. Again, the date of the survey, number of nets, duration of netting, moon phase, temperature and other environmental parameters should be standardized as much as possible in order to compare data

between years. A preferred time of annual netting would be during female lactation, between late June and mid-July, and before the monsoon season creates additional water sources. Echolocation signals should also be recorded at the same time with the Anabat system.

1. Water sources should be enhanced so that they are accessible to bats dipping for water on the wing. Tanks and springs are magnets to bats and other wildlife in arid areas. Bat activity in an area should be monitored (watching with night vision equipment, mist-netting and acoustic recording) before and after water development projects to determine their effectiveness.

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